Consulting Assistance on Economic Reform II

DISCUSSION PAPERS

The objectives of the Consulting Assistance on Economic Reform (CAER II) project are to contribute to broad-based and sustainable economic growth and to improve the policy reform content of USAID assistance activities that aim to strengthen markets in recipient countries. Services are provided by the Harvard Institute for International Development (HIID) and its subcontractors. It is funded by the U.S. Agency for International Development, Bureau for Global Programs, Field Support and Research, Center for Economic Growth and Agricultural Development, Office of Emerging Markets through Contracts PCE-C-00-95-00015-00 and PCE-Q-00-95-00016-00. This paper is funded by Contract PCE-Q-00-95-00016-00, Delivery Order 15.

Internet Use and Telecommunications Infrastructure

David Canning

CAER II Discussion Paper 54
December 1999

For information contact:
CAER II Project Office
Harvard Institute for International Development
14 Story Street
Cambridge, MA 02138 USA
Tel: (617) 495-9776; Fax: (617) 496-9951
Email: caer@hiid.harvard.edu

Internet Use and Telecommunications Infrastructure[1]

David Canning

December 1999

Correspondence:
Professor David Canning
School of Management and Economics
Queen's University Belfast
Belfast BT71NN
Northern Ireland
U.K.

e-mail: d.canning@qub.ac.uk
phone: 44-1232-273281

[1] The author would like to thank Orest Koropecky of USAID for his comments on the paper.

Abstract

We undertake a cross-country study of the determinants of Internet use, focusing on the effect of the quantity, quality and pricing of the telephone system. We find that the extent of the telephone network does have a significant impact on Internet use, influencing how quickly countries gain access to the Internet, as well as the level of use once connected. We also find that the provision of Internet hosts is closely linked to the quality of the telephone network. The results suggest a policy of developing telecommunications infrastructure in developing countries in order to exploit the benefits of the Internet.

I. Introduction

The Internet promises to be a very important tool of economic development, allowing developing countries to integrate more fully into world markets and speeding the advent of globalisation. While the recent introduction of the Internet does not allow a meaningful evaluation of its economic impact, studies on the effect of other forms of infrastructure, such as telephone systems, suggest that a large impact on economic growth is possible (see, for example, Gramlich (1994), World Bank (1994), Sanchez-Robles (1998), and Canning (1999)). Given the desirability of a high level of Internet use, it is interesting to investigate what factors are influential in determining the extent of Internet use in a country. Two obvious factors are the size and level of income of a country. In this paper we investigate the role of an additional range of factors, focusing on the quantity, quality, and pricing of the telephone system.

A great number of studies have used survey data to study the determinants of Internet use (e.g. Klobas and Clyde (1998), Lan and Falcone (1997), and Teo and Tan (1998)). However, these studies tend to focus on the income and attitudes of adopters versus non-adopters, rather than the effect of services such as telephone provision.

Using cross-country data from 1995 for 153 countries we investigate how different measurements of Internet use—such as the number of Internet users, the number of packets of information sent to the Internet, and the number of Internet hosts—vary with indicators of telephone supply. We find strong evidence that the level of Internet use is closely linked with the extent of the telephone system. However, the high degree of correlation between the extent of the system, the quality of the system, and low telephone charges makes it difficult to disentangle exactly which feature is most important as a determinant of Internet use.

In this study, we find that the major determinant of the number of Internet hosts in a country is the quality of the telephone system, as measured by the percentage of lines that are digital and the lack of faults per line. We find little effect of either network size or pricing policy on the number of Internet hosts.

A problem with our approach to estimating the relationship between Internet use and telephone provision is that we use only countries that have some Internet use and ignore countries that do not have Internet use. This has the potential for inducing a sample selection bias in the results. We overcome this problem by employing a two-stage procedure. First, we discuss whether a country has any Internet access at all, and if it has, the second stage is to discuss the level of that access. Using this approach we find that telephone provision has a significant impact on whether a country has any access to the Internet, as well as the volume of Internet use once access has been established. This suggests that the telecommunications system may be an important determinant of the inception of Internet use. This effect of the telephone system on Internet use suggests that it has a distinct role in gaining access to the Internet, in addition to its role in overcoming congestion effects once the Internet has become established (for the congestion effect argument see Lee and Sharma (1998) and Sidak and Spulber (1998)).

A notable feature of our results is that while we find strong links between the extent and quality of telephone provision and Internet use, we find little evidence of a link between telephone

charges and Internet use. That is, our data show that the price of a three-minute local telephone call seems to have little effect on Internet use. However, this may be due simply to the high degree of correlation between the extent and quality of the telephone system and low prices, which makes it difficult to pinpoint effects precisely.

If we accept a strong link between the extent and quality of the telephone system and Internet use, we have an added incentive to improve the telephone provision. While it is possible to access the Internet by other means—for example via satellite (Kassel (1998))—the telephone system remains a major channel for Internet access. The problem of an inadequate telephone network is particularly acute in developing countries, where telephone provision per capita is much lower, proportionately, than their income levels relative to that of developed countries (Canning (1998)). This strengthens the case for competition and deregulation in the telecommunications industry argued by Harris and Kraft (1997), Spiller and Cardilli (1997), Waverman and Sirel (1997), Jayakar (1999), Madden and Savage (1999), and Yoon (1999). Gains in telephone productivity and provision may have the added benefit of encouraging greater use of the Internet.

II. Data

We use three types of data on Internet use. The first is the number of Internet hosts in the country. This is a comprehensive survey carried out by "pinging" all domain names and counting the number of returns. While this method is comprehensive, we do have a problem with hosts that are not registered to a specific country domain. We assume all hosts in the .com, .mil, .gov, and .edu domains are in the United States, but do not assign hosts in the .org domain to any particular country.

The second type of data on use that is available is the number of packets of information that enter the Internet that originate from each domain. This is perhaps the best "volume" measurement of usage.

Finally we have data from surveys asking people if they use the Internet. This allows us to construct estimates of the total number of people with access to the Internet in a country. While this measure is interesting, it is only available for a limited number of countries. All data are for 1995.

Data on population size and real income per capita (at purchasing power parity) come from the World Bank (1998). For the telephone system, we have as quantity measures data on the number of main telephone lines and the number of international lines. An alternative to using quantity data would be to use data on investment to construct a capital stock measure. However, as Pritchett (1996) points out, investment data is not a reliable guide to the value of the capital created because prices differ across countries. As quality measures, we have the number of faults per line per year and the percentage of lines that are digital. Hulten (1996) argues that the impact of infrastructure, such as telephones, depends more on the quality of the service rather than the quantity of provision. Finally, we have price data on the residential connection charge, monthly line rental, and cost of a three-minute local telephone call (in cases where a three minute call was

free we used a nominal figure of $0.01). Data on the telephone system come from the International Telecommunications Union (1997) with data on main lines supplemented with data from Canning (1998).

III. Empirical Results

We start by trying to explain cross-country variations in the number of packets of information sent to the Internet. A potential problem with our approach is reverse causation from Internet use to the characteristics of the telephone system. Indeed, Internet telephony is now seen as a major potential competitor to the standard telephone system (Mason (1998)). This suggests that the widespread use of the Internet may have major effects on the use and pricing of the phone system. However, as of 1995, the size and accessibility of Internet telephony and its impact on telecommunications providers were very small. We therefore proceed on the assumption that all of our explanatory variables can be considered exogenous.

We begin, in column (1) of table 1, by trying to explain the log number of packets of information transmitted through the Internet by log population and log income per capita. In column (1), the coefficient on population is very close to one, indicating that, holding income per capita constant, communication with the Internet goes up one for one with population. On the other hand, a 1% increase in income per capita leads to a 3% rise in communication with the Internet, indicating that Internet use rises much more than proportionately with income. Both variables are statistically significant (t ratios are calculated allowing for the variance of the random disturbances to vary across countries).

In column (2) of table 1 we add to the regression a range of variables indicating the quantity, quality, and price of telephone system. Adding this large a number of variables reduces the precision of the estimates and none of the newly included variables are statistically significant. However, if we proceed by eliminating the variable with the lowest significance level and re-estimating, and repeating this until all the remaining variables are significant at the 10% level, we produce the results reported in column (3). Now main lines per capita appear to be a significant determinant of Internet use, as is the monthly line rental charged to phone users.

The idea that Internet usage increases with the provision of phone lines seems reasonable. However, it is difficult to explain why Internet use might rise with the cost of the monthly line rental. A high monthly line rental might deter people from having a telephone, but the number of telephones is already included in the regressions, and so should pick up this effect. In any case we would expect the effect of a high monthly line rental to be to deter telephone ownership and so have a negative rather than positive effect on Internet use. When we drop the monthly line rental fee from the regressions (in column (4)) the main line effect persists. Since most Internet connection is made through a local call, we might expect the price of a local call to have a negative effect on Internet use. However, this does not seem to be the case; we could not find a specification in which the price of a three-minute call was statistically significant.

We should be hesitant, however, about interpreting the results of column (4) in table 1 as saying that the number of telephone main lines is the only important component of the telephone service

Table 1. The telephone system and Internet use.

Dependent Variable: Log Packets of Information sent to Internet 1995

	(1)	(2)	(3)	(4)
Constant	-27.3 (6.20)	-13.9 (1.97)	-19.9 (3.89)	-22.7 (5.13)
Log Population	0.991 (6.32)	0.956 (5.02)	0.973 (5.93)	0.970 (6.75)
Log Income per Capita	3.063 (10.8)	1.541 (1.54)	1.902 (3.44)	2.344 (6.25)
Log Telephone Main Lines per Capita		1.036 (1.58)	0.785 (2.34)	0.701 (2.71)
Log International Connections per main line		0.151 (0.51)		
Log faults per main line		0.357 (0.73)		
Log percentage main lines digital		-0.378 (0.62)		
Log residential connection charge		-0.003 (0.01)		
Log Monthly line rental		0.359 (1.02)	0.467 (2.05)	
Log price of a three minute call		0.348 (1.01)		
N	73	51	68	73
R^2 adjusted	0.632	0.682	0.672	0.659

t statistics in parentheses are heteroskedastic-consistent

for Internet use. In table 2 we regress the number of main telephone lines per capita on the other explanatory variables in the model. One interpretation of the results in table 2 is to treat them as demand relationships. In this case, column (1) of table (2) indicates that the demand for main line rises with income and falls with the monthly line charge and the price of a three-minute call. The results in column (2) suggest that demand also falls as the quality of the system (measured by the number of faults per line) declines.

However, interpreting table 2 as a demand relationship is only valid if the prices and service quality are set exogenously by telephone companies and the number of main lines are demand determined. In fact, prices may respond to demand pressure in some circumstances and, when they do not, telephone provision is often rationed leading to long waiting lists. If this is the case, we must regard table 2 as support for a statistically significant relationship between the factors, but must not assume it indicates a causal relationship. Even in this case, the strong statistical link between a high level of telephone provision, a low telephone charge, and a high quality of service, means that in practice it will be difficult to isolate the separate influences of these different factors. It may be best to think of the level of provision of main lines per capita as a proxy measure for the overall level of service of telecommunications infrastructure.

In table 3, we report the results of regressions explaining the level of Internet use among the population. In column (1) we find, as for packets of information, that the number of users tends to rise one for one with population and more than proportionately with income per capita. Adding information on the telephone system does not seem to improve the fit, though when we do this the sample size becomes quite small. Parsing down the specification as for packets of information does not leave any of the telephone variables significant. Column (3) of table 3 reports a regression where telephone main lines is used as a proxy for the overall level of telephone service provision, but again this variable is not significant.

We now turn to the number of Internet hosts in a country; results are reported in table 4. While the number of hosts rises with income per capita, the effect of population size is relatively small and statistically insignificant. This implies that two countries with the same level of income per capita should have a roughly equal number of Internet hosts, independent of their population size. One possible explanation for this phenomenon is that the demand for variety in Internet sites varies with the level of income. However, a rise in Internet usage caused by a rise in population may be met mainly by increasing the server capacity at a fixed number of sites, rather than increasing the number of sites. That is, if we have more people we have more demand for existing sites rather than demand for different sites.

When we add our telephone variables we find that the number of faults per main line has a dominant effect on the number of Internet hosts. This variable even makes the effect of income per capita become insignificant (its coefficient changes sign). This indicates that the quality of the telephone system may be a key factor in promoting the setting up of Internet sites.

Dropping insignificant telephone variables one at a time leads us to the specification used in column (3). In this specification, the provision of Internet hosts seems to fall with the number of faults per line but rise with the percentage of lines that are digital. This supports the theory that the main factor influencing the provision of hosts is the quality of the telephone system, rather than its extent or pricing schedule. Using main lines per capita as a proxy for the overall level of

Table 2. Main lines per capita as an indicator of telephone provision.

Dependent Variable: Log Main Lines per Capita 1995

	(1)	(2)
Constant	-10.18 (9.98)	-7.754 (6.67)
Log Population	-0.005 (0.09)	-0.041 (1.01)
Log Income per Capita	1.440 (15.5)	1.322 (12.6)
Log faults per main line		-0.250 (3.29)
Log residential connection charge	-0.053 (0.79)	-0.044 (0.62)
Log monthly line rental	-0.181 (2.05)	-0.236 (2.74)
Log price of a three minute call	-0.320 (3.96)	-0.313 (3.55)
N	137	112
R^2 adjusted	0.723	0.799

t statistics in parentheses are heteroskedastic-consistent

Table 3. The telephone system and the number of Internet users.

Dependent Variable: Log Internet Users 1995

	(1)	(2)	(3)
Constant	-25.7 (10.4)	-23.9 (2.76)	-23.9 (8.30)
Log Population	0.979 (11.7)	1.060 (4.15)	0.958 (11.0)
Log Income per Capita	2.438 (15.6)	2.401 (3.00)	2.229 (8.07)
Log Telephone Main Lines per Capita		0.036 (0.07)	0.168 (1.033)
Log International Connections per main line		-0.039 (0.12)	
Log faults per main line		-0.111 (0.58)	
Log percentage main lines digital		-0.576 (0.92)	
Log residential connection charge		-0.155 (0.90)	
Log Monthly line rental		0.017 (0.04)	
Log price of a three minute call		-0.004 (0.02)	
N	44	27	44
R^2 adjusted	0.908	0.824	0.910

t statistics in parentheses are heteroskedastic-consistent

Table 4. The telephone system and the number of Internet hosts.

Dependent Variable: Log Internet Hosts 1995

	(1)	(2)	(3)	(4)
Constant	-6.594 (1.46)	16.40 (1.91)	5.637 (0.77)	-8.608 (1.58)
Log Population	0.168 (1.06)	0.198 (0.56)	0.220 (1.21)	0.165 (1.00)
Log Income per Capita	1.336 (3.41)	-1.024 (0.98)	-0.182 (0.35)	1.673 (3.01)
Log Telephone Main Lines per Capita		0.175 (0.23)		-0.327 (0.93)
Log International Connections per main line		0.096 (0.14)		
Log faults per main line		-1.734 (3.10)	-1.256 (2.97)	
Log percentage main lines digital		1.199 (1.37)	1.058 (1.79)	
Log residential connection charge		-0.155 (0.41)		
Log Monthly line rental		-0.110 (0.19)		
Log price of a three minute call		0.165 (0.381)		
N	66	43	50	66
R^2 adjusted	0.151	0.212	0.274	0.149

t statistics in parentheses are heteroskedastic-consistent

telephone services, in column (4) does not give a statistically significant result which suggests that it is indeed the quality of service, rather than a more general overall measure, that matters.

A potential problem with our approach is that we discuss Internet use only in countries where some use is recorded. In over half our sample of countries there was no Internet use in 1995. This brings us to an interesting question; what determines if a country has any Internet use at all, as opposed to the extent of Internet use in countries that record some Internet use? There is also the problem that ignoring countries that have no Internet use in our estimation leads to biases in our estimates since the inclusion of any given country in our study is non-random.

To address these issues we use a two-stage model to estimate the relationship in question, predicting both the probability that a country will have any Internet access as well as the level of Internet access under the condition that some Internet use has been recorded for the country. The results of this approach are reported in table 5. The upper part of table 5 gives the results of a probit regression explaining the dummy variable “Internet use.” For example, the "packet dummy" takes the value zero for countries that sent no packets and the value one for countries that did. The lower part of table 5 explains the level of use in countries where there is use. We report results for the number of hosts and the number of packets. In these cases a zero for the dummy variables means the country lacks any Internet activity while a one indicates some activity. However, for the data on the number of users we rely on the completion of a household survey, and we must account for the possibility that the lack of data may imply merely the absence of a survey, rather than the lack of Internet use. In this case a first stage regression would only determine the characteristics of countries where a survey took place, as opposed to those with no survey, which is not our real interest.

The results in table 5 show that our telephone variables seem to affect whether or not a country has any Internet access in 1995, as well as the level of Internet access it achieves once a connection is in place. In column (1) of table 5 we find that countries with large populations, high per capita incomes, and high level of main lines per capita are more likely to be connected to the Internet than others. The same factors also appear to increase the level of use once Internet connections exist. In column (2) of table 5 we drop the role of main line telephones in promoting use once connections are made because of its low level of statistical significance. In this regression, main lines per capita have an impact on the existence of Internet use even at the 5% significance level.

A similar two-stage regression approach for Internet hosts gives the results reported in columns (3) and (4) of table 5. These results suggest that the presence of Internet hosts is more likely in large countries (i.e. those with large populations) and those with a high level of main lines per capita. However, once some Internet hosts do exist, the level of income per capita seems to be more important in determining the level of Internet use. Two-stage regressions used to study the number of hosts failed to find significant effects of the quality of the telephone network—the number of faults per line and the proportion of the system that was digital—that were so important in the simple regressions in table 4.

Table 5. Two-stage regressions: Internet access and the level of use.

	(1)	(2)	(3)	(4)
dependent variable	packet dummy	packet dummy	host dummy	host dummy
constant	-11.75 (5.81)	-11.41 (5.77)	-3.034 (1.92)	-3.132 (2.04)
log population	0.411 (5.13)	0.406 (5.19)	0.145 (2.58)	0.144 (2.57)
log income per capita	0.583 (2.41)	0.547 (2.35)	0.011 (0.06)	0.026 (0.15)
log main lines per capita	0.281 (1.85)	0.302 (1.97)	0.271 (2.28)	0.262 (2.33)
	(1)	(2)	(3)	(4)
dependent variable	log packets	log packets	log hosts	log hosts
constant	-24.05 (2.69)	-25.34 (2.47)	-16.13 (1.81)	-15.29 (1.69)
log population	1.007 (2.68)	0.939 (4.24)	0.039 (1.31)	0.357 (1.35)
log income per capita	2.402 (3.48)	2.941 (4.24)	1.760 (2.42)	1.788 (2.73)
log main lines per capita	0.733 (1.66)		0.107 (0.21)	
sigma	1.985 (1.01)	2.077 (1.50)	3.654 (3.98)	3.481 (4.30)
rho	0.117 (0.60)	-0.146 (0.75)	0.737 (2.22)	0.662 (1.80)
N (percent positive)	153 (47.7)	153 (47.4)	153 (43.1)	153 (43.1)

t statistics in parentheses

The results in table 5 suggest that the telephone system may be more important in the question of whether or not a country has any Internet activity rather than the level of activity once activity is taking place. This suggests that the size and quality of the telephone system play important roles in determining how quickly developing countries gain access to the Internet.

IV. Conclusion

We have found evidence that the quantity and quality of telecommunications services provided in a country is a significant determinant of the existence of Internet connections and the level of Internet use, even after we take account of a country's income level. In particular, the presence of any access to the Internet at all depends on the extent of that country's telephone network. This implies that in developing countries the telephone system may be crucial for the inception of Internet use. In addition, once it is connected, the level of use is also tied to the number of telephone main lines a country provides. On the other hand, the provision of Internet hosts, which may be the most important variable in terms of business use of the Internet as a tool for international marketing, is dependent on the quality of the telephone system, particularly the number of faults and the percentage of the lines that are digital.

These results point towards a policy of developing telecommunications infrastructure, particularly in developing countries, as a necessary condition for promoting Internet use. As well as focusing on the extent of the telephone system, our conclusions suggest emphasis should be placed on the quality of the system being provided. Only a high quality system will allow the development of international e-business by local firms who aim to sell their products in international markets through the use of Internet hosts.

References

Canning D. (1998), "A Database of World Infrastructure Stocks, 1950-1995," *World Bank Economic Review*, Vol. 12, pp 529-548.

Canning D. (1999), "Telecommunications and Aggregate Output," Consulting Assistance on Economic Growth II Discussion Paper No. 56, Harvard Institute for International Development.

Gramlich E. M. (1994), "Infrastructure Investment: A Review Essay," *Journal of Economic Literature*, Vol. XXXII, pp 1176-1196.

Harris R.G. and Kraft C.J. (1997), "Meddling Through: Regulating Local Telephone Competition in the United States," *Journal of Economic Perspectives*, Vol. 11, No. 4, pp 93-110.

Hulten C.R. (1996), "Infrastructure Capital and Economic Growth: How Well You Use It May Be More Important Than How Much You Have," mimeo, University of Maryland.

International Telecommunications Union (1997), *World Telecommunications Indicators on Diskette,* Geneva.

Jayakar K.P. (1999), "Local Exchange Competition in Early US Network Development: Considerations for Developing Countries," Telecommunications Policy, Vol. 23, pp 375-387.

Kassel A. (1998), "Internet Access by Satellite: How to Get It, How It Works," *Online*, Vol. 22, pp 30 –34.

Klobas J.E. and Clyde L.A. (1998), "Learning to use the Internet in a Developing Country: Validation of a User Model," *Libri*, Vol. 48, pp 163-175.

Lan Z.Y. and Falcone S. (1997), "Factors Determining Internet Use—A Policy Model for Electronic Government Information Provision," *Journal of Government Information*, Vol. 24, No. 4, pp 251-257.

Lee L.T. and Sharma P. (1998), "The Internot? Understanding the Problem of Internet Congestion," Journal of Media Economics, Vol. 11, pp 13-31.

Madden G. and Savage S.J. (1999), "Telecommunications Productivity, Catch-up and Innovation," *Telecommunications Policy*, Vol. 23, pp 65-81.

Mason R. (1998), "Internet Telephony and the International Accounting Rate System," *Telecommunications Policy*, Vol. 22, pp 931-944.

Melody W.H. (1999), "Network Diffusion Policies," *Telecommunications Policy*, Vol. 23, pp 361-362.

Pritchett L. (1996), “Mind Your P's and Q's, The Cost of Public Investment is Not the Value of Public Capital,” Policy Research Working Paper, No. 1660, Policy Research Department, World Bank.

Sanchez-Robles B. (1998), “Infrastructure Investment and Growth: Some Empirical Evidence,” *Contemporary Economic Policy*, Vol. XVI, pp 98-108.

Sidak J.G. and Spulber D.F. (1998), “Cyberjam: The Law and Economics of Internet congestion of the Telephone Network,” *Harvard Journal of Law and Public Policy*, Vol. 21, pp 327-394.

Spiller P.T. and Cardilli C.G. (1997), “The Frontier of Telecommunications Deregulation: Small Countries Leading the Pack,” *Journal of Economic Perspectives*, Vol. 11, No. 4, pp 127-138.

Teo T.S.H. and Tan M. (1998), “An Empirical Study of Adopters and Non-Adopters of the Internet in Singapore”, *Information and Management*, Vol. 34, pp 339-345.

Waverman L. and Sirel E. (1997), “European Telecommunications Markets on the Verge of Full Liberization,” *Journal of Economic Perspectives*, Vol. 11, No. 4, pp 113-126.

World Bank (1994), *World Development Report, Infrastructure for Development*. Washington D.C.

World Bank (1998), *World Development Indicators*, Washington D.C.

Yoon C.H. (1999), “Liberalisation Policy, Industry Structure and Productivity Changes in Korea’s Telecommunications Industry”, *Telecommunications Policy*, Vol. 23, pp 289-306.